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मानक

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Mazdoor Kisan Shakti Sangathan

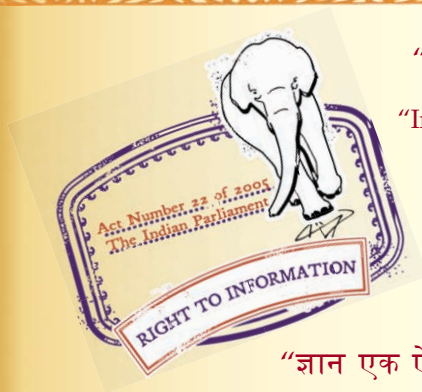
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“Step Out From the Old to the New”

IS/IEC 519-3 (1988): Safety in Electroheat Installations, Part 3: Particular Requirements for Induction and Conduction Heating and Induction Melting Installations (Superseding IS 9080 (Part 3)) [ETD 17: Industrial Electroheating Equipment]



“ज्ञान से एक नये भारत का निर्माण”

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“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक
विद्युत ताप संस्थापनों में सुरक्षा

भाग 3 प्रेरण और चालन तापन एवं प्रेरण गलन संस्थापनों की विशिष्ट अपेक्षाएँ

Indian Standard
SAFETY IN ELECTROHEAT INSTALLATIONS
PART 3 PARTICULAR REQUIREMENTS FOR INDUCTION AND CONDUCTION HEATING AND
INDUCTION MELTING INSTALLATIONS

ICS 25.180.10

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NEW DELHI 110002

July 1997

Price Group 8

NATIONAL FOREWORD

This Indian Standard which is identical to IEC Pub 519-3 (1988) 'Safety in electroheat installations — Part 3 : Particular requirements for induction and conduction heating and induction melting installations' was adopted by Bureau of Indian Standards on the recommendations of the Industrial Electroheat Equipment Sectional Committee, ET 17, and approval of the Electrotechnical Division Council.

While taking up the revision of IS 9080 (Part 3) : 1979 'Safety requirements in electroheat installations : Part 3 Particular requirements for mains and medium frequency induction furnace installations', the Sectional Committee decided to align the standard with the corresponding IEC 519-3 (1988). This standard supersedes IS 9080 (Part 3) : 1979.

The text of IEC Standard has been approved as suitable for publication as Indian Standard without deviations.

In this standard, certain terminology and conventions are not identical with those used in Indian Standards. Attention is specially drawn to the following :

- a) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

In this standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence :

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 50 (841) : 1983 International electrotechnical vocabulary, Chapter 841 : Industrial electroheating	IS 1885 (Part 17) : 1979	Technically equivalent
IEC 364-4-41 : 1983 Electrical installations of buildings, Chapter 41 : Protection against electric shock	IS 2309 : 1989	Technically equivalent
IEC 519-9 : 1984 Safety in electroheat installation, Part 1 : General requirements	IS/IEC 519-1 (1984)	Identical

*Indian Standard***SAFETY IN ELECTROHEAT INSTALLATIONS****PART 3 PARTICULAR REQUIREMENTS FOR INDUCTION AND CONDUCTION HEATING AND
INDUCTION MELTING INSTALLATIONS****1. Scope**

1.1 This standard shall be read in conjunction with IEC Publication 519-1.

1.2 It consists of:

- a general section covering requirements common to both induction and conduction heating installations and induction melting installations and,
- two sections, A and B, giving specific requirements for each type of installation.

1.3 *The standard applies to*

- installations for induction and conduction heating of solids, at low, medium and high frequencies. (For conduction heating, use of direct current is also included);
- installations for induction melting, holding and superheating at low, medium and high frequencies;
- those parts of the conveying or handling equipment of the electro-heat installation, which are within the influence of the heating section.

Examples of application:

Installations for induction and conduction heating of slabs, billets, rods, strip, wire, tubes, rivets, etc., for subsequent hot forming and heat treatment.

Installations with induction crucible furnaces or induction channel furnaces.

2. Definitions

Note.- Terms relating to this publication are defined in IEC Publications 519-1 and 50(841).

Terms which are not defined in IEC Publication 519-1 but considered essential for this publication are presented as follows.

2.1 *Induction heating* (IEV 841-05-01, modified)

Method of heating in which the heat is generated by currents in the charge, induced electromagnetically.

2.2 *Conduction heating* (direct resistance heating)
(IEV 841-02-02 modified)

Resistance heating in which current passes through the material to be heated and is not induced electromagnetically.

2.3 *Heating section*

That part of the equipment in which heating by induction or conduction takes place.

2.4 *Inductor* (IEV 841-05-06 modified)

The component (e.g., coil(s)) of induction heating or melting equipment, carrying an alternating current and designed to create the magnetic field which induces currents in the charge (IEV 841-10-13).

2.5 *Contact system*

The component of a conduction heating work station by which the charge is electrically connected to the heating circuit.

2.6 *Induction crucible furnace* (IEV 841-05-18)

An induction melting or holding furnace in which the heat is generated directly in the charge, or in the crucible containing it by means of one or more inductor coils arranged around the crucible.

2.7 *Induction channel furnace* (IEV 841-05-19)

An induction melting or holding furnace forming a transformer whose secondary circuit comprises the molten metal contained in a channel made of refractory material and which is connected to a refractory lined chamber also containing molten metal, into which charge pieces to be heated are placed.

3. Inductor

3.1 Where the inductor or parts of it are intended to be replaced due to wear or exchanged to meet a new production requirement, the manufacturer's instructions shall be followed.

3.2 Should the effect of cooling of the inductor become insufficient and cause danger to personnel or damage to essential parts of the equipment, an alarm signal shall be given and the heating power switched off automatically.

- 3.3 Cooling of the inductor below dew point should be avoided as it may cause condensation at the coil and its terminals leading to possible short-circuit.
- 3.4 For electroheat equipment with forced cooled inductors having a charge and/or lining of high heat capacity, it is advisable to have an emergency supply for cooling the coil(s) and where applicable the conveying equipment until the hot charge has been removed and until the lining has cooled to a safe temperature level.
- 3.5 The voltage applied to inductors, for example, coils with tappings, shall not exceed the manufacturer's rating.

4. Capacitors

- 4.1 All necessary precautions shall be taken to rapidly discharge capacitors which may be dangerous to touch after they have been switched off.

A warning notice shall be displayed in a prominent position stating that the discharge has to be effected before handling the capacitors.

- 4.2 For capacitors permanently connected in parallel to an inductor work coil or a transformer, the discharge device may be dispensed with.

Where capacitors connected in parallel to an inductor or a transformer are disconnected only in the off-load condition, the discharge device may be dispensed with, providing a sufficient time delay occur for the discharge between switching off the supply and opening of the capacitor switch.

Note.- If there is a risk of d.c. charging, the discharge device is indispensable.

- 4.3 Capacitors which are switched on load or connected via external fuses shall have discharge facilities.
- 4.4 A discharge device is not a substitute for short-circuiting the capacitor terminals together and to earth before handling.

Note.- Although a discharge device has operated, a residual charge may sometimes be left at the interconnections of series-connected capacitors due to blown fuses, interrupted internal connections, differences of the capacitance values or dielectric recharging from d.c. components of the previous charge.

- 4.5 Capacitors for low frequencies shall be connected via protective devices. Where internal fuses are employed, external means of protection can be dispensed with. Capacitors for medium and high frequencies may be connected without protective devices.
- 4.6 In the case of liquid-cooled capacitors, the capacitor temperature shall be monitored by a device fitted with an automatic alarm. If the cooling systems of several capacitors are connected in series, it will suffice to monitor the temperature of the capacitor at the outlet end. Where the capacitor units are individually switched, the last unit in the series-connected cooling circuit shall be permanently connected in the electrical circuit, or be the last unit to be disconnected.
- 4.7 Instead of the capacitor temperature, the temperature of the coolant at the outlet point or rate of flow of each cooling circuit may be monitored.

5. Mains frequency power sources

In the case of mains frequency power sources which feed a single phase load from a three-phase supply and which employ capacitors and reactors to keep the 3 line currents in reasonable balance, series resonance causing overvoltages liable to impair safety may occur if the phase connection common to the capacitors and reactors of the balancing circuit becomes open-circuited, for example, by a blown fuse or a defective contactor in the line.

For such conditions measures shall be provided to disconnect the supply, for example, overvoltage tripping of the supply circuit breaker.

Contactors which control the three-phase supply to the reactor-capacitor combination shall be designed to ensure that the contact connected to the common point of the reactor and capacitor closes early when switching on and opens late when switching off.

6. Motor-alternator frequency converters

- 6.1 In the case of rapid power reduction or switching in of capacitors, transient voltages may occur which the heater and frequency converter shall be designed to tolerate.
- 6.2 The excitation current shall only be applied when the frequency converter has reached its operating speed and the starting sequence has been completed.

6.3 The alternator shall be provided with overcurrent and overvoltage protection. Protection devices shall include time dependent elements to match the transient characteristics of the alternator. Thermal protection devices are normally not suitable because of their inertia.

6.4 If there is a risk of voltage peaks which are inadmissible even if of short duration, direct acting protection devices shall be employed, for example surge arresters. Series-compensated frequency alternators shall include suitable protection, for example series capacitor short-circuiting devices.

6.5 In the case of frequency convertors without automatic voltage control switching-in of capacitors or power reduction by switching operations shall only be possible when the generated voltage is at a safe level.

7. Solid state frequency converters

7.1 Solid state frequency converters shall be protected at the input terminals to prevent transient overvoltages which may occur during switching operations on the supply side, ensuring that safety is maintained.

7.2 Solid state frequency converters shall have quick-acting over-voltage and overcurrent protection.

7.3 Additional measures shall be taken to avoid the occurrence of dangerous transient voltages due to rapid changes of load power.

8. Ferromagnetic frequency multipliers

8.1 Ferromagnetic frequency multipliers considered in this standard are of the conventional three-phase/single phase type.

The multiplier consists of a special connection of highly magnetically saturated cores of single-phase reactors, i.e., chokes or transformers, which shall comply with the standards of transformers with regard to cooling, control and safety requirements.

8.2 On the three-phase input side of a multiplier, capacitors and reactors shall be connected so as to compensate high magnetizing currents of the multiplier reactors as well as to limit the harmonic content in the supply currents.

9. Switchgear

9.1 Design of on-load operated switchgear of motor alternator frequency converters shall take into account the voltage characteristics of the converter for sudden load decreases.

- 9.2 Design of off-load operated switchgear shall take into account the time behaviour of the converters, reactances (transformers and reactors) and capacitors.
- 9.3 Design of switchgear shall take into account not only the fundamental component of the current, but also the harmonic content which may be produced by the installation.
- 9.4 When switching capacitors on-load, the following points among others shall be considered when a choice of switching device or method is made:
- When switching on, high current peaks at high frequency may occur.
 - When switching off, critical levels of overvoltage as a result of restriking of the switching device shall be avoided.

10. Cables, wires and busbars

- 10.1 Cables, wires and busbars shall be so dimensioned that inadmissible heating is avoided, taking into account the magnitude and frequency of their current loadings.

Note.- Tables of cable current carrying values relevant for mains frequency (50 Hz/60 Hz) are generally not applicable for installations working at higher frequencies.

In the case of parallel connections, care shall be taken to avoid over-heating of individual conductors due to unequal sharing of current.

- 10.2 Where cables, wires or busbars are forced cooled, the provisions given in Sub-clauses 6.2.8, 6.5.1 and 6.5.2 of IEC Publication 519-1, shall apply.
- 10.3 The installation's individual overcurrent protection devices may be dispensed with for internal connections between components such as frequency multipliers, converters, transformers, capacitors, switchgear, inductors and contact systems, provided such connections are short-circuit and earth-leakage proof.

Note.- This is deemed to be the case with cables or arrangements of solid wires or single cores where contact with one another (also with earthed parts) is prevented by using sufficient clearances, spacers or insulating shims, by laying the conductors in separate conduits of insulating material or by using cables or wires that are considered to be short-circuit proof by their design.

The short-circuit strength mentioned above can be dispensed with for medium and high-frequency installations if sufficient short-circuit protection is ensured by the design of the frequency converter, for example solid state equipment.

- 10.4 Cables and wires which are part of the heating section are normally provided with an insulation that shall resist high mechanical and thermal stresses. In the majority of cases this insulation is insufficient for protection against electric shock. For this reason measures shall be taken for the prevention of inadvertent contact with these cables and wires during operation, if the permissible touch voltage (Sub-clause 14.1.1) is exceeded.

11. Liquid cooling (see IEC Publication 519-1, Sub-clause 6.5)

- 11.1 The formation of bubbles in cooling systems of high-frequency equipment of voltage band 3 shall be avoided, as arcing may occur in the bubbles liable to deteriorate the cooling system.
- 11.2 In textile reinforced hoses moisture may creep along the textile reinforcement thus creating potential differences between the reinforcement and the coolant, possibly exceeding the electrical resistance of the hose wall.

This shall be taken into account in the choice of material and the disposition of hoses.

- 11.3 Certain liquid-cooled components (e.g., ceramic capacitors, water jackets of electronic valves) are extremely sensitive to pressure. Deviating from the requirements of Sub-clause 6.5.4 of IEC Publication 519-1, they shall only withstand the rated service pressure. Their water connections however shall withstand 1.5 times the rated service pressure.

12. Rating plate (see IEC Publication 519-1, Clause 8)

The principal components of the electroheat installation (for instance, inductor, contact system) shall have individual rating plates.

13. Clearance and creepage distances

The clearances and creepage distances employed for high frequency and medium frequency installations are not necessarily those used for mains frequency (50 Hz/60 Hz).

Where reduced values are employed (for example, in high-frequency generators) measures shall be taken to prevent flashovers impairing safety.

14. Protection against electric shock (see IEC Publication 519-1, Clause 12)

14.1 *Protection against direct contact* (see IEC Publication 364-4-41, Clause 412)

14.1.1 *Permissible touch voltage as a function of frequency*

The limit of permissible touch voltage is a function of frequency; this limit increases with frequency. Recommended limit levels are under consideration and where national standards exist they shall apply.

Note.- Care should be taken where a high-frequency voltage is modulated by one of a lower frequency.

14.1.2 All parts of the heating installation having electrical equipment, for example capacitors, reactors, transformers, inductors or contact systems, switchgear, cables and busbar connections, shall be located inside enclosures or be otherwise adequately protected against direct contact. It shall not be possible to open the doors or remove the covers giving access to those parts of the equipment with voltages of bands 2 and 3 without the use of a tool, for example, a spanner or a lock, the key of which is available only to an authorized person.

14.1.3 Live conductors at voltage bands 2 and 3 shall be inaccessible except where the following conditions exist:

Voltages in band 2: access only by authorized persons. In addition for voltages in band 3, the design shall be such as to prevent inadvertent contact by authorized persons who are carrying out fault finding, testing and repair. This may be achieved, for example, by one or more of the following methods:

1) *Use of bolted-on covers:*

Access only intended with power switched off.

2) *Hinged lockable doors or hinged internal screens:*

A positively operated, non-resettable safety switch shall be fitted to ensure that the door is closed before restoration of power and means provided to bring out leads of appropriate specification to externally connected test instrumentation.

3) *Internal screens and insulation:*

Internally fixed screens or insulation shall be employed covering positions where voltage test points are required; the screen shall have holes or slots of dimensions to allow insertion of test probes.

14.1.4 Accessible plugs and sockets etc. for d.c., a.c. or high-frequency voltages greater than 500 V which must not be interchangeable shall be automatically switched off before or when being disconnected in service to avoid hazard of safety to personnel; this may be achieved by use of mechanical interlocks .

14.2 *Protection against indirect contact* (see IEC Publication 364-4-41, Clause 413)

14.2.1 *Permissible touch voltage as a function of duration and frequency*

As stated in Sub-clause 14.1.1 the permissible touch voltage increases with frequency. This shall be taken into consideration when drawing information from the existing values of limit levels for mains frequency, d.c. and voltage band 2 given in Sub-clause 413.1.1.3, Table 41A and Figure 41B of IEC Publication 364-4-41 (see Appendix A).

The permissible touch voltage as a function of frequency for continuous contact is identical with the permissible touch voltage for direct contact (see Sub-clause 14.1.1).

Limit levels for voltage band 3 and for frequencies other than mains are under consideration.

14.2.2 The electrical insulation resistance of parts of the electroheat installation varies throughout the process cycle due to changes of temperature, the electrical insulation, lining and electrical components, for example, capacitors, water-cooled windings and particularly the temperature and quality of water employed.

A value of minimum electrical insulation resistance is normally not given and therefore it is necessary to take these variations into account when setting the operating levels of protective devices, for example earth leakage detection at the time of commissioning the installation.

Induction heating installations often have considerable leakage currents. This may necessitate electrical isolation of the electroheat installation from the power supply mains.

14.3 *Special requirements*

14.3.1 Metal rings and bracelets shall not be worn near strong electromagnetic fields of medium and high frequencies (e.g., in the vicinity of inductors).

14.4 *Earthing provisions* (see IEC Publication 519-1, Sub-clause 12.4)

- 14.4.1 If live parts are connected to earth, via resistors, impedances or arresters in an installation which is electrically isolated from the supply mains, the earth connections shall be dimensioned thermally and dynamically for the highest current occurring in case of fault. The current flowing in these earth connections shall be monitored. If the maximum limit admissible in operation is exceeded, an alarm shall be given and the installation switched off automatically.

Monitoring is not necessary in the case of connections that serve for the discharge of electrostatic charges or the like and in high-frequency applications where the inductor is protected by guards which, when removed, prevent operation of the heater.

- 14.4.2 When using protective earthing, consideration shall be given to the frequency dependence of the loop impedance formed by the current source, the active conductors and the earthing system.

- 14.4.3 It may be necessary to operate, without connection to earth, metal parts which are directly influenced by the electromagnetic field, in order to avoid closed metal loops and thereby maintain electromagnetic and thermal effects within acceptable limits; in which case other means of protection shall apply. See Sub-clause 12.3 of IEC Publication 519-1.

Where these parts are liable to be at a voltage exceeding the permissible touch voltage level (see Sub-clause 14.2.1) access by operating personnel shall not be possible. If this cannot be avoided for reasons of space requirements or due to the mode of operation of the installation, protection of personnel shall be ensured by other means given in the operating instructions.

- 14.4.4 All sheathed cables, conduits or pipes passing through those parts of an enclosure containing high-voltage circuits in the voltage band 3 shall be earthed at the point where they pass through the enclosure.

- 14.4.5 In high-frequency generators, circuits of voltage band 3 may be employed using the earthing provisions for the supply system of voltage band 2, providing the overload monitoring of the supply transformer interrupts the high-voltage circuit immediately.

Note. - Individual earthing generally required for distribution systems of voltage band 3 can be dispensed with for the high-frequency circuits of generators because of low values of short-circuit power which exist within the high-frequency circuits.

14.5 *Protective conductors*

The permissible material for protective conductors for low-frequency equipment is copper, aluminium or galvanized steel strip. For medium or high-frequency equipment copper or aluminium should be used.

On dimensioning the cross-sectional areas, due consideration shall be given also to the discharge current of capacitors.

The penetration depth of the current decreases with increase of frequency. This shall be taken into consideration when dimensioning the cross-sectional area of the protective conductor.

15. Radio interferences

Care should be taken to avoid radio interferences when electroheat equipment is operated. Guidance may be given by national or international standards.

SECTION A

SPECIFIC REQUIREMENTS FOR INDUCTION AND
CONDUCTION HEATING INSTALLATIONS

A1. Conveying equipment and charge

- A1.1 The conveying equipment shall be capable of withstanding the effect of temperature from the charge.

Design of the conveying equipment shall take into account the effects of the electromagnetic fields. In addition to employing suitable materials and geometries this may necessitate further measures, such as screening, isolation, avoidance of closed metallic loops and forced cooling to keep electromagnetic and thermal effects within acceptable limits.

The effect of the electromagnetic forces acting on the charge shall also be catered for in the design.

- A1.2 Design of the conveying equipment shall be suitable for changes in the volume and physical strength of the charge which occur during the heating process.

- A1.3 Charge pieces having dimensions, shape, physical properties, burrs and tolerances as agreed between user and manufacturer shall be employed to ensure the safe working and correct operating sequence of the heating installation.

- A1.4 Measurement of surface temperature does not allow reliable assessment of the temperature distribution in the charge due to specific physical phenomena. Therefore, possible overheating of the charge cannot be excluded. Attention should be given to minimize this risk, for example, by compliance with the operating instructions.

- A1.5 Presence of metallic residues, i.e., scale, may interfere with the progress of the charge and affect the reliability and safe working of the heating installation. When necessary, scale and residue shall be removed in accordance with the manufacturer's instructions.

- A1.6 Where the conveying equipment or part of it is forced cooled, for example, water-cooled, refer to Sub-clauses 3.4 and A2.7.

A2. Contact system

- A2.1 Where the contact system or parts of it are intended to be replaced due to wear or exchanged to meet a new production requirement the manufacturer's instructions shall be followed.

A2.2 The value of contact pressure given by the manufacturer shall be maintained throughout the period when heating power is switched on by use of a suitably designed device, for example, a locking system which can only be opened by a power-operated release mechanism and with heating power switched off.

A2.3 During normal operation, contacts shall close or open only with the heating power switched off to prevent arcing and voltage surges; provision in the design shall be made to prevent scatter of hot metal which may cause danger to personnel and equipment.

A2.4 In the case of a rapidly moving charge (for example, tubes) measures shall be provided to prevent surface irregularities from damaging contact systems or their holding mechanism, for example, by allowing these to be moved from the path of such irregularities.

A2.5 In applications where contact systems are used without electrical insulation, the equipment shall be designed, for example, with protective screens or sufficient distance, such that in normal use inadvertent contact with the bare contact system is not possible. This applies where the permissible touch voltage is exceeded (see Sub-clause 14.1.1).

Where use of protective screens or other means of protection is not possible, a warning notice shall be displayed on the installation and compliance made with Sub-clause 12.2 of IEC Publication 519-1.

A2.6 Should the effect of cooling of the contact system become insufficient and thus cause danger to personnel or damage to essential parts of the equipment, an alarm signal shall be given and the heating power shall switch off automatically.

A2.7 For heaters with forced cooled contact systems having a charge of high heat capacity, it is advisable to have an emergency supply for cooling the contact system and where applicable the conveying equipment also, until the hot charge has cooled to a safe temperature level or has been removed.

A3. Inductor (see Clause 3)

A3.1 In applications where inductors are used without electrical insulation, for example, hardening, brazing or annealing, the equipment shall be designed, for example, with protective screens or sufficient distance, such that in normal use inadvertent contact with the bare conductor is not possible. This applies where the permissible touch voltage is exceeded (see Sub-clause 14.1.1).

Where use of protective screens or other means of protection is not possible, a warning notice shall be displayed on the installation and compliance made with Sub-clause 12.2 of IEC Publication 519-1.

A4. Special requirements (see Sub-clause 14.3)

A4.1 For induction heating equipment used for pipework, container or boiler manufacture, treatment or repair, in application fields where safety regulations normally allow only operating voltages of band 1, voltages of band 2 also may be applied, where necessary, providing the following precautions are taken:

- Use of motor-alternators or transformers having separate windings; the transformers having an extra-high dielectric strength and a high insulation resistance to earth;
- Use of equipotential connections which provide a safe area of contact to operating personnel, otherwise insulating gloves and footwear shall be used. The circuit shall at no point be connected to earth, except via an insulation monitoring system.

If it is not possible to avoid direct or indirect contact with live parts where the insulation is insufficient to prevent electric shock, as is the case with water cooled heating cables, the use of insulating clothing or tools is necessary.

A5. Earthing provisions (see Sub-clause 14.4)

The charge and the moving parts of the conveying system usually cannot be solidly earthed or included in a protective system, in which case other means of protection shall apply. See Sub-clause 12.3 of IEC Publication 519-1.

SECTION B

SPECIFIC REQUIREMENTS FOR INDUCTION
MELTING INSTALLATIONSB1. Tilting device

In furnaces equipped with a tilting device, the following requirements shall be met:

- B1.1 In the event of failure of the tilting mechanism, the furnace shall remain in the position reached or slowly tilt back to its normal position. Tilting back to its normal position shall be possible without danger.
- B1.2 If, during tilting, there is a danger of the workman falling into the well normally covered by the furnace platform, protective measures shall be provided to avoid this danger. These measures shall not create other hazards, e.g., cutting or squeezing.
- B1.3 In the case of a hydraulic tilting device, the pump, the hydraulic fluid reservoir and the piping shall be so positioned as to be protected against any eventual damage due to accidental outflow of molten metal.
- B1.4 The tilting movement shall be limited in both directions.
- B1.5 If, during tilting, live parts are accessible, energizing the furnace shall only be possible when the furnace is in its normal position.
- B1.6 In the case of hydraulic tilting, activating levers shall automatically return to zero.
- B1.7 With tilting devices of any kind, push-buttons and levers shall be of the non-maintained type in the switched-on position.

B2. Furnace foundations

- B2.1 There shall be a receiving well or a ladle pit capable of taking the total amount of molten metal in the case of emergency tilting or a breakthrough. The receiving well or the ladle pit shall be protected by barriers or covers.
- B2.2 The area beneath the furnace shall be designed to allow the molten metal to flow into the receiving well in front of the furnace at a rate fast enough to avoid consequential damage to the furnace and other parts of the installation in the event of a breakthrough.
- B2.3 The presence of water in the receiving well or the ladle pit or below the furnace shall be avoided because of the possible danger of explosion due to contact with molten metal.

B3. Lining

B3.1 Molten metal breaking through the furnace lining represents a hazard to personnel and equipment. The lining thickness varies throughout its operating life. Furthermore sudden deteriorations for example by thermal and mechanical shocks may be experienced.

B3.2 The state of the furnace lining shall be checked at reasonable intervals. This may be effected by:

- a) Evaluation of electrical values of the installation.
- b) Visual inspection.
- c) Measurement of the crucible diameter at different heights (crucible furnaces).
- d) Temperature control (inductor case and coolant of channel furnaces).

B3.3 In order to increase safety to operators and to reduce risk of damage to the furnace, due to the electrical insulation deterioration below a critical value together with the possibility of a breakthrough of the refractory lining, it is recommended that alarm devices and means to disconnect the supply to the furnace should be provided.

B4. Operation

B4.1 Overheating of the molten metal shall be avoided. This is effected by:

- a) the rate of power input;
- b) the charging procedure.

B4.2 Care shall be taken that the charge enters the bath according to the progress of the melt to keep its temperature within acceptable limits.

B4.3 The charging procedure shall not lead to freezing of the metal surface or fusion of scrap pieces above the bath (bridging).

B4.4 To avoid overheating, measurement of the temperature of the molten metal shall be made in accordance with the instructions of the manufacturer.

B4.5 Special precautions shall be taken when charging materials or pieces with cavities which may contain moisture into the bath of metal because of the risk of eruptions of molten metal.

B4.6 Dangerous, noxious or toxic fumes or gases liable to be generated during melting shall be evacuated by means of an appropriate device.

B5. Earthing provisions (see Sub-clause 14.4)

- B5.1 The charge usually can be connected to earth by an earthing electrode, the effectiveness of which shall be ensured. Where earthing is not possible, other means of protection shall apply. See Sub-clause 12.3 of IEC Publication 519-1. It is also recommended to use an insulation monitoring device in accordance with Sub-clause B3.3.

APPENDIX A

ADMISSIBLE TOUCH VOLTAGE AS A FUNCTION
OF DURATION

TABLE 41A

Maximum prospective touch voltage duration

Maximum disconnecting time (s)	Prospective touch voltage	
	a.c., r.m.s. (V)	d.c. (V)
∞	<50	<120
5	50	120
1	75	140
0.5	90	160
0.2	110	175
0.1	150	200
0.05	220	250
0.03	280	310

Notes 1. – The d.c. column of Table 41A is related to ripple-free d.c., for example from batteries. If the source of supply is rectified a.c. the a.c. column figures would apply. Specific values for rectified a.c. are under consideration.

2. – The prospective touch voltage on d.c. equipment can be of different waveform from the system voltage and is dependent on the fault circuit parameters.

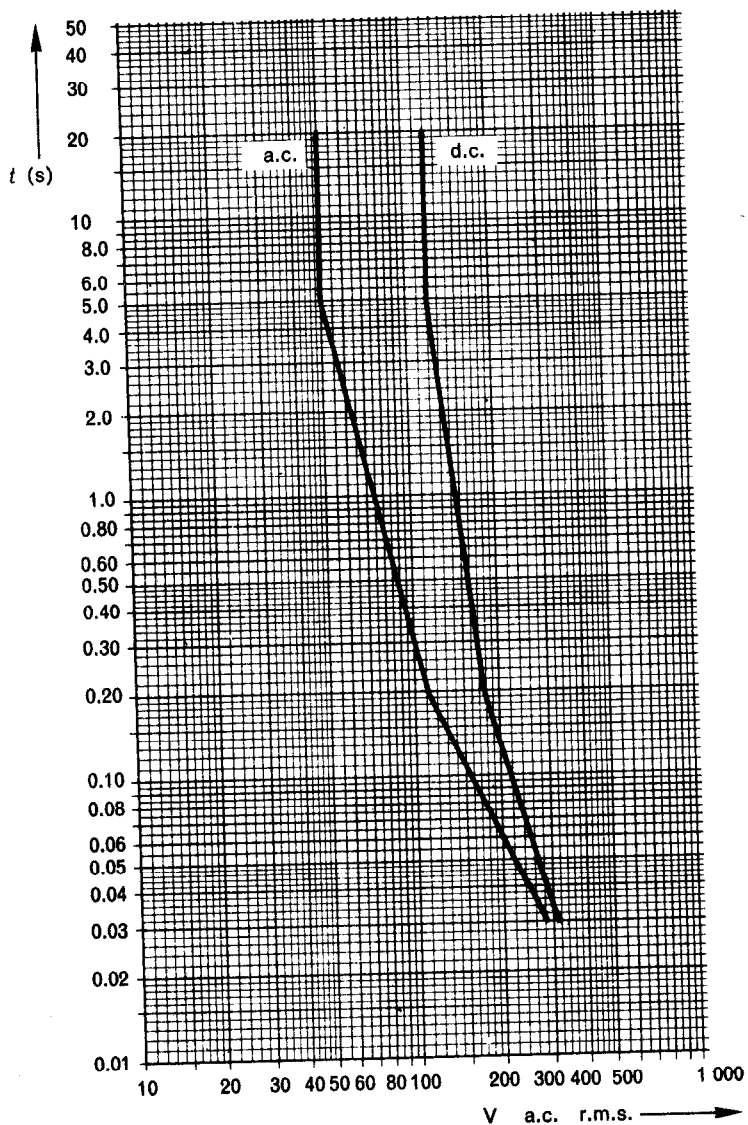


Fig. 41B. - Maximum prospective touch voltage duration curves according to Table 41A.